LUMBER AND ITS UTILIZATION

STRONGER FRAME WALLS

NATIONAL LUMBER MANUFACTURERS ASSOCIATION

VOL·IV·CH·18 CONSTRUCTION INFORMATION SERIES

INTRODUCTION

Scientific, laboratory tests now offer the builder, master carpenter, architect, and engineer dependable facts on the relative merits of various methods of framing buildings. Recent damage to masonry and frame buildings in several areas subject to tornadoes and hurricanes has emphasized the need of some definite data as to the resistance against wind pressures that may be expected from the various framing methods.

In cooperation with the National Lumber Manufacturers Association, the United States Forest Products Laboratory has just completed tests on nearly fifty wall panels. These tests now offer the builder definite information on the strength and rigidity that may be expected from horizontal sheathing, diagonal sheathing, herringbone bracing, let-in-braces, plaster and wood lath, etc.

In this bulletin, the results are graphically summarized on the first two pages. Then follows a detailed report on the method of test and a description of the individual tests.

NATIONAL LUMBER MANUFACTURERS ASSOCIATION

CASLON PRESS, INC.
WASHINGTON, D. C.

STRONGER FRAME WALLS

Graphic Summary of Laboratory Tests of Strength and Rigidity of Lumber Framing

(For comparative purposes, test results for different framing methods are expressed in relation to the strength or rigidity of a horizontally sheathed, unbraced panel.)

Rigidity is measured by the end thrust necessary to cause a given movement of the end posts from their upright position.

Strength is measured by the end thrust necessary to cause failure of the panel.

Effect of Sheathing Methods

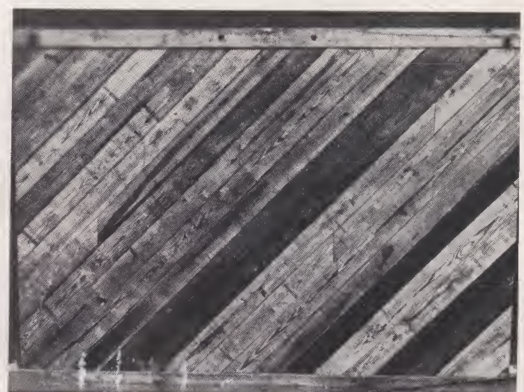
Panel I

WALL PANEL I

This is a horizontally sheathed unbraced wall panel, nailed with 8d nails. Other framing methods illustrated are compared with it.

WALL PANEL II

This is a diagonally sheathed, 8d nailed, unbraced panel. It is 7 to 8 times as strong and 4 to 7 times as rigid as Wall Panel I.



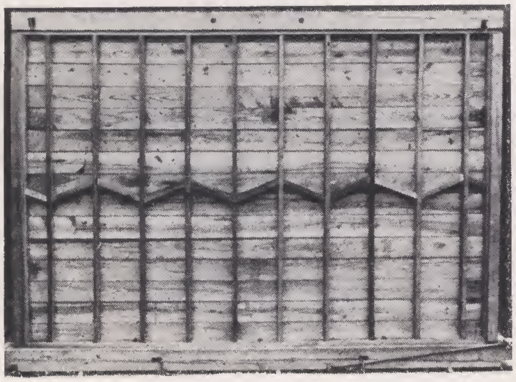
Panel II

Panel III

WALL PANEL III

This is a panel of plaster on wood lath without sheathing after test. It is 4½ times as strong and 7 times as rigid as Wall Panel I.

Effect of Various Bracing Methods



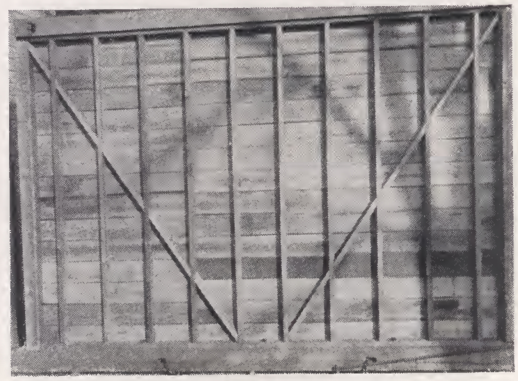
Panel IV

WALL PANEL IV

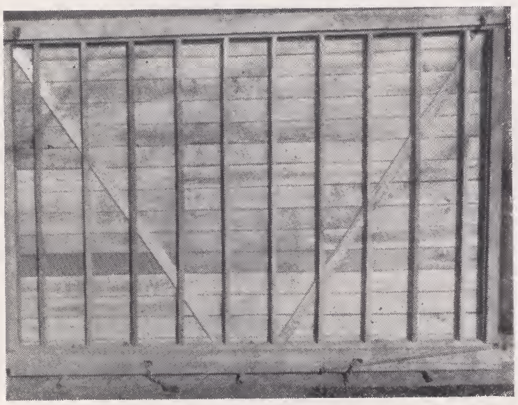
This is the same type of framing as Wall Panel I, except that herringbone bracing has been added. Herringbone bracing adds about one-tenth to the strength and one-third to the stiffness of a horizontally sheathed panel.

WALL PANEL V

In this panel instead of herringbone bracing 2x4 cut-in braces have been used. They add 25% to strength and 60% to rigidity.



Panel V



Panel VI

WALL PANEL VI

In this panel 1x4 let-in strips have been let in the stud faces diagonally. They make the horizontally sheathed wall 3½ times to 4 times as rigid as Wall Panel I.

Effect of Window and Door Openings

WALL PANEL VII

In a horizontally sheathed wall, window and door openings, closed spaced, reduce the rigidity 30% and strength 20%. However, diagonal let-in-braces more than offset the weakening effect of window and door openings.

Panel VII

Panel VIII

WALL PANEL VIII

In a diagonally sheathed wall, window and door openings reduce the rigidity 63% and strength 50%. Such walls, however, unbraced, are still much better than horizontally sheathed walls without openings.

(A table summarizing the complete test results is given on page 11)

STRONGER FRAME WALLS

Government Laboratory Tests Show How to Frame Buildings to Withstand High Wind Pressures

RECENTLY completed tests at the U. S. Forest Products Laboratory, Madison, Wisconsin, answer many long-standing questions about design of light framed buildings and show how vastly to increase both strength and stiffness in comparison with current practice.

For years builders have been told that diagonal sheathing makes a much stronger and more rigid frame house than horizontal sheathing. No one could say what the difference was; whether it justified the additional expense; or whether the weakening influence of windows and doors in the wall offset the benefits of diagonal sheathing. Are diagonal strips, let into the studs, better or poorer bracing than 2x4 corner braces cut in between studs, or herringbone bridging at half story heights? Do three nails in each board make a wall stronger and more rigid than two nails?

These and many other questions must have occurred to thousands of master carpenters, builders, architects and engineers charged with producing a strong, rigid and permanent frame structure. They were given point by tornadoes and hurricanes which in the last few years alone have wrecked thousands of buildings of both frame and masonry construction, and by earthquake insurance rates which in some parts of the country far exceed those for fire.

Definite answers to these questions as they affect lumber construction are available from the series of tests just completed by the U. S. Forest Products Laboratory. In order to make the tests complete and give helpful data for other forms of sheathing and siding invitations were submitted to the Celotex Company and the Sheet Steel Manufacturers Association to participate in the tests, but each of these organizations declined. Prefacing its work by personal investigations in a number of storm damaged areas, the Laboratory decided that the walls contribute most to the strength and rigidity of a building as a whole. The government engineers determined also that typical, lumber framed and sheathed walls are strong enough to resist any pressure likely to be caused by wind blowing directly against them. Wall resistance to end thrust, caused when the pressure against the front is transmitted to the side walls, is a more critical point. (See Fig. 1.)

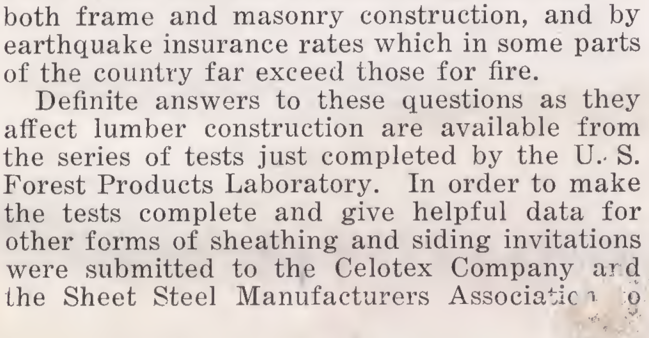


Figure 1

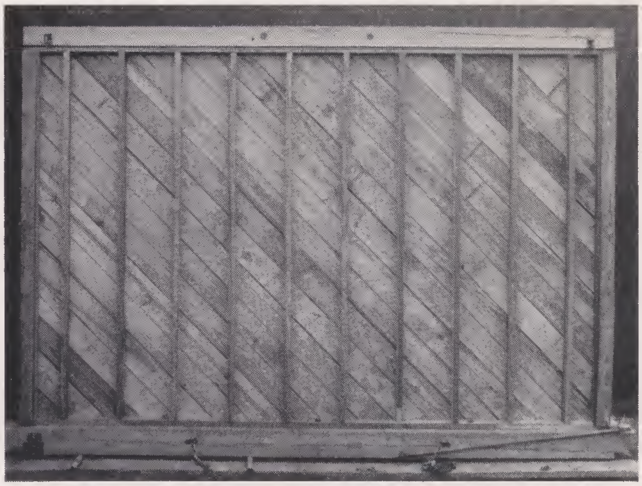


Fig. 2—Panel set up for test. The stirrup at the lower right hand corner prevents the sole plate from moving. End thrust is applied at the upper left hand corner, in the plane of the panel.

With this in mind, the Laboratory built and subjected to end thrust nearly fifty frame walls of full story height, (8 and 9 feet) and long enough, (12 and 14 feet) to show how a real wall would act under extreme conditions. These walls were framed with 2x4's at the usual 16 inch spacing; the sole plate was bolted to a fixed base, and pressure was applied horizontally at the top plate in the plane of the wall surface. End posts, corresponding to the corner posts of a house, were built up in the usual way with three 2x4's. (See Fig. 2.)

Both the rigidity of the walls, as shown by the end thrust necessary to cause a given movement of the end posts from their upright position, and the strength, as evidenced by the end thrust necessary to cause failure of the whole

panel, were measured. The results are expressed using the average strength and stiffness of a double-nailed horizontally sheathed panel as a basis. Thus, if we take as (1) the strength of the horizontally sheathed panel with two nails in each board at each stud, the strength of a diagonally sheathed panel will be about (8), or eight times as much. If the stiffness of the horizontally sheathed panel is also taken as (1), that of the diagonally sheathed panel with the boards in compression is about (7). (See Tables 1 and 2, page 11).

Conclusions From Tests

The tests covered the following principal factors effecting strength and rigidity of light framing:

1. Frequency of nailing.
2. Size of nails.
3. Inclination of sheathing.
4. Types of bracing.
5. End matching.
6. Seasoning of lumber.
7. Effect of window and door openings.
8. Effect of lath and plaster.
9. Effect of vibration.

Frequency of Nailing

Three nails per stud in horizontal sheathing boards do not increase the wall stiffness appreciably, since the middle nail of the three is about at the center of the resistance couple set up by the outside nails. It acts, in other words, just as though it was the only nail in the board.

Four nails per stud in 1 x 8 inch horizontal sheathing increase the strength and stiffness about 40%. (See Fig. 3.) The resistance of the inner pair of nails to twisting is naturally less than that of the outside pair.

The effect of more nails on diagonal sheathing is much more important. Here the sheathing boards act with the framing as tension or compression members of a small truss, and each additional nail holding them in place adds considerably to the strength of the whole. Three nails instead of two increased the stiffness from 3.8 average to 5.2 and four nails brought it up to 7.5. Increases in strength were not measured, but were well beyond any strength likely to be required of frame construction.

Size of Nails

When a horizontally sheathed panel gives way, due to end thrust, it is usually the nails which give way first. They bend and twist before the wood splits. Heavier nails therefore might be expected to make a stiffer, stronger panel, and such in fact was the case. Two 10d nails instead of two 8ds increased stiffness of a horizontally sheathed panel 50% and strength 40%. When 12d nails were used strength and stiffness fell off again, perhaps because the large shanks split the boards more seriously.

Larger nails than 8d made little improvement in strength of diagonally sheathed panels, because the boards are not twisted about the studs when such panels resist pressure, and the greater strength of the nails was not brought into play.

Inclination of Sheathing

With two 8d nails per stud, a diagonally sheathed panel is about eight times as strong, and from four to seven times as stiff as a similar panel horizontally sheathed. When it is real-

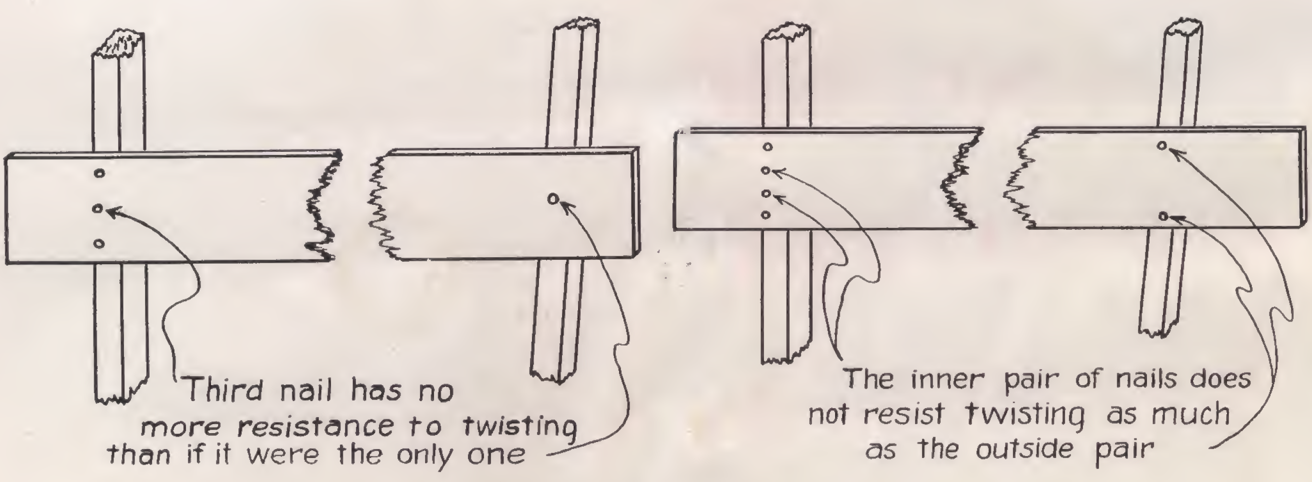


Figure 3—Nailing Efficiency.

ized that this tremendous increase is secured in the average building with very little sacrifice of time and material, it is hard to believe that sheathing will continue to be used horizontally to any extent.

Types of Bracing

Several types of bracing are in common use to stiffen frame walls. Three of these methods were tested. Herringbone bracing, (Fig. 4) or "fire-stopping" as it is sometimes wrongly called, increased the stiffness of a horizontally sheathed panel only 30% and the strength only 10%. Two by four braces cut in between the studs, (Fig. 5), brought improvements of 60% and 40%.

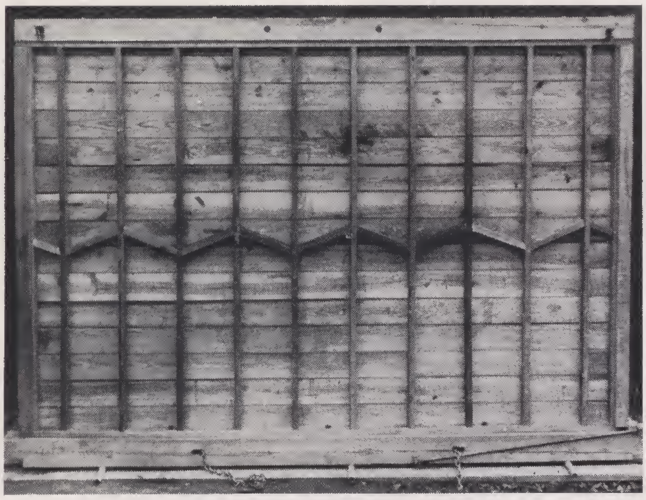


Fig. 4—Panel with "herringbone" bracing. Little added stiffness due to bracing, and fire-stopping effect much inferior to that of similar blocking at story lines.

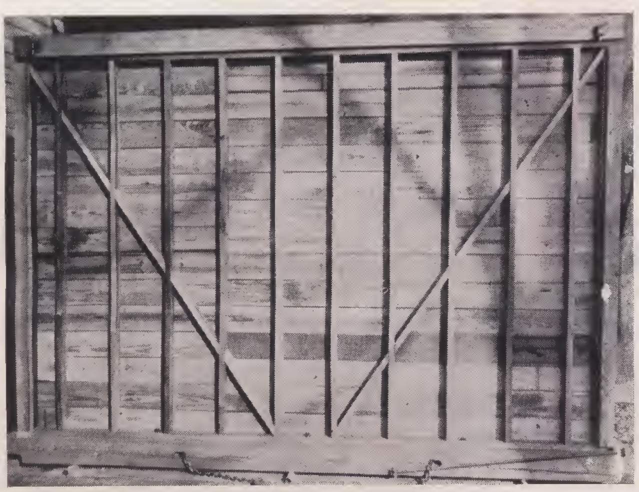


Fig. 5—Diagonal 2x4 inch cut-in braces improve stiffness 60% and strength 40%. Tightly fitted ends are essential if full benefit is to be had from them.

The important discovery made in this field was that 1x4 inch strips, let into the faces of the studs beneath horizontal sheathing, (Fig. 6), increase the stiffness from two and one-half to four times, and strength about three and one-half times. For situations such as in farm buildings, airplane hangars and small garages, where sheathing is omitted and siding applied horizontally, the let-in bracing strips offer far the best assurance of stiffness and strength.

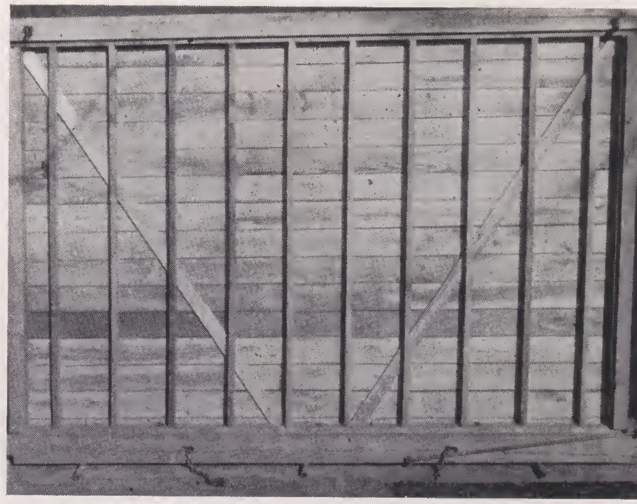


Fig. 6—Braces of let-in strips are far the most effective, increasing stiffness 2½ to 4 times, and strength about 3½ times.

End Matched Sheathing

Relatively few builders have had experience with the side and end-matched, roofing and sheathing boards just becoming commercially available. Their advantage is that the ends do not have to be butted over the studs and no sawing is necessary except at openings or corners. Waste is almost eliminated.

Tests were made to find out if walls thus sheathed are as strong and rigid as when the boards are butted over the studs. One by six inch side and end-matched boards gave as good results as 1x8 butt-edged boards.

Seasoning of Lumber

In some parts of the country, and particularly on farms or for low-grade building operations, buildings are often built of green or partly dried lumber. Results are seldom satisfactory. To discover what happens when such lumber dries out two panels were sheathed horizontally and two diagonally with green lumber. These were given a month under cover to dry out, and were then tested. The horizontally sheathed panels lost in drying about 40% of the normal stiffness and 30% of the strength of dry-sheathed panels. The diagonally sheathed panels decreased in relative stiffness from about 4 to 1.7. Strength tests were not made after seasoning. (See Figures 7, 8 and 9.)

The test described represents of course the most extreme conditions likely to occur as a result of using green lumber, and it would appear that several other factors may have as much or more influence on stiffness and strength than the use of green lumber. In this connection note the results of vibration tests described later.

Fig. 8—Panel horizontally sheathed with green lumber, after seasoning for thirty days. Cracks represent 5⅛ inches shrinkage in 9-foot height. Moral. Use dry lumber.

Fig. 7—Green horizontal sheathing when first nailed on to frame.

Fig. 9—View of panel diagonally sheathed with green lumber and allowed to season one month. Stiffness reduced 55%.

Effect of Window and Door Openings on Strength and Rigidity of Framed Walls

Openings reduce the resistance of a wall to longitudinal thrust. (See Table 2). A double 28-inch window in a diagonally sheathed wall reduced its stiffness about 20% and its strength about 40%. Adding a 3x7 foot doorway decreased the stiffness about 65% and the strength 50%. The wall was still twice as rigid and several times as strong as a horizontally sheathed wall with the same openings. Certain critical positions of openings may cause even greater reductions, but are not likely to occur under practical conditions.

Fig. 10—A window opening framed in a diagonally sheathed panel reduced its stiffness 20% and its strength about 40%.

Framing a door and window into a horizontally sheathed panel decreased strength and stiffness 20% and 30% respectively. Results of numerous other combinations may be seen in Table 2. (See Figures 10, 11 and 12.)

Fig. 11—A door and a window in a 9x14 foot diagonally sheathed panel reduce the stiffness 63% and the strength 50%. It is still much better than a horizontally sheathed panel without openings.

Fig. 12—Diagonal, let-in braces on a horizontally sheathed panel more than make up for the weakening effects of doors and windows. Relative stiffness is 1.5; strength is 2.2.

Effect of Wood Lath and Plaster on Strength and Rigidity of Framed Walls

Wood lath and plaster, according to the tests, contribute surprisingly to strength and stiffness of a building. Installed on a panel without sheathing it afforded seven times the stiffness and four times the strength to be expected from horizontal sheathing. It increased the stiffness of a horizontally sheathed panel with window and door openings over 200%. Wood lath and plaster with horizontal sheathing and let-in braces around openings as in Fig. 12 made a panel slightly stiffer than diagonal sheathing with the same openings, and nearly as strong.

The influence of wall and partition openings in causing plaster cracks is thoroughly apparent from the results with plastered panels. A thrust of 8,000 to 12,000 lbs. causing the top plates to move about 3/8 inch, was applied before cracks appeared in the panels without openings. A thrust of 800 to 1500 lbs. with only a few hundredths of an inch movement caused cracks in those with openings. The cracks in Figures 13 and 14 show plainly the direction of stress and the tendency towards plaster cracks around openings. Cracks like those in Fig. 14 are often

observable in wind-racked houses and like those in Fig. 13 in almost any poorly framed or braced structure.

Effects of Vibration

The question naturally occurs as to whether the extra stiffness and strength of walls, secured by bracing, diagonal sheathing or other expedients will survive the loosening effects of many storms, occurring throughout the life of a building. To discover what these effects might be, several panels were set in a vertical position on the table of a large box-testing machine. This machine is designed to jerk a box of merchandise, placed on its table, sharply back and forth, imitating the racking and swaying effect of railroad or truck transportation.

In this instance the "throw" of the machine table on which the panel was placed was such as to jerk out of plumb at each vibration about two-thirds as far as it would go under regular pressure test without sustaining permanent damage. Two horizontally sheathed panels were thus subjected to 50,000 cycles of vibration. One panel was horizontally sheathed with green lumber, allowed to dry out one month, and then given 1,000,000 cycles of vibration.

Fifty thousand cycles, 100,000 severe endwise jerks, did not decrease the stiffness or strength of the dry-sheathed panels perceptibly. The losses in stiffness and strength of the green-sheathed panel after 2,000,000 jerks was only what might be expected of a green-sheathed panel subsequently dried out.

Significance of Tests

Over four-fifths of the houses in this country are of frame construction. When the number

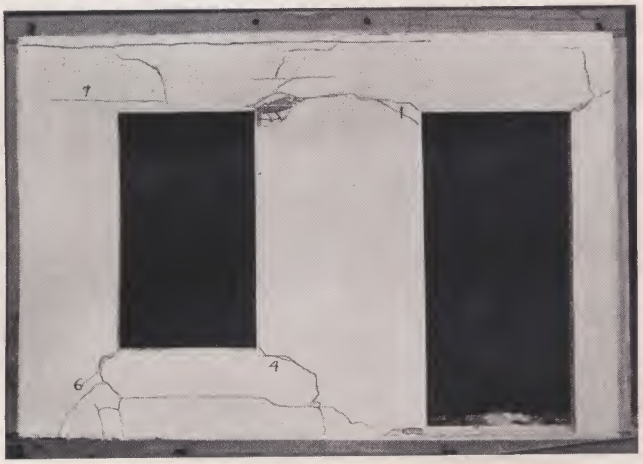


Fig. 13—Wood lath and plaster panel after test. The lath and plaster compensates for the weakening effect of openings.

Fig. 14—Plaster cracks show plainly the direction of stress.

of garages, shops, barns and other farm buildings built of lumber are added to this total, the significance of the tests becomes apparent. Easily a billion dollars is expended on lumber farm buildings annually. Perhaps another billion is spent on small garages, on airplane hangars and other light framed structures. Much more is expended on dwellings.

Present framing methods are giving satisfactory performance; even in areas subject to hurricanes and tornadoes, but they can be improved. It is no longer a matter of guess work as to which framing or bracing method will give the best results, as the series of tests described in this report furnish information as to the various degrees of strength and rigidity that may be expected by the different framing and bracing methods. Perhaps the most significant result of the tests is the establishment of the fact that much greater strength and wind resistance can be built into frame buildings at little, if any, additional cost.

A few simple precautions, such as use of diagonal sheathing; or effective let-in bracing, the use of heavier nails on horizontally sheathed structures or of more nails on those diagonally sheathed; the employment of wood lath and plaster with its tremendous stiffening influence on the structure; and of reasonably dry lumber, will increase the strength and stiffness of buildings many times over that now generally realized, and will extend their consequent prospect of structural durability correspondingly. In portions of the country threatened constantly with earthquakes or destructive winds, the further consideration of safety to life makes it almost imperative that the benefit of such precautions be widely advertised and certain features perhaps included in building codes.

SUMMARY OF TEST RESULTS

(All test results expressed on basis of comparison with the stiffness and strength of a 8-inch horizontal sheathed unbraced panel)

TEST OF PANELS WITHOUT WINDOW AND DOOR OPENINGS
(TABLE 1.)

Description of Panel * Panel frames consisted of 2 by 4-inch upper and lower plates, vertical studs spaced 16 inches, and triple end posts	Stiffness factor	Maximum Load Pounds	Strength factor
8-inch horizontal sheathing, two 8d nails, no braces) †“ “ “ “ “ “ “ “ “) †“ “ “ “ “ “ “ “ “) “ “ “ “ “ “ “ “ “)	1.0	2,588	1.0
8-inch diagonal sheathing, two 8d nails, no braces, boards in tension	4.3	‡	Over 8
“ “ “ “ “ “ “ “ “ “ “ “	4.3	17,100	6.6
“ “ “ “ “ “ “ “ “ “ “ “	2.8	‡	Over 8
“ “ “ “ “ “ “ “ “ “ “ compression	7.3	20,100	7.8
8-inch horizontal sheathing, two 8d nails, herringbone or bridge 2 by 4-inch braces	1.3	2,800	1.1
“ “ “ “ “ “ “ , cut-in 2 by 4-inch braces	1.6	3,700	1.4
“ “ “ “ “ “ “ , let-in 1 by 4-inch braces, first arrangement	2.6	9,250	3.6
“ “ “ “ “ “ “ , “ “ “ “ “ “ “ , second arrangement	4.2	9,000	3.5
8-inch horizontal sheathing, three 8d nails, no braces	1.0	2,300	0.9
“ “ “ “ , four “ “ “ “	1.4	3,550	1.4
8-inch diagonal sheathing, three 8d nails, no braces, boards in tension	5.2	‡	Over 8
“ “ “ “ , four “ “ “ “ “ “ “	7.5	‡	Over 8
8-inch horizontal sheathing, two 10d nails, no braces	1.5	3,500	1.4
“ “ “ “ , two 12d “ “ “	1.3	2,800	1.1
8-inch diagonal sheathing, two 10d nails, no braces, boards in tension	5.1	‡	Over 8
6-inch horizontal sheathing, two 8d nails, end and side matched, no braces	1.0	2,550	1.0
Plaster on wood lath, no sheathing	7.2	11,400	4.4
“ “ “ “ , 8-inch horizontal sheathing, two 8d nails, no braces	7.9	14,500	5.6
“ “ “ “ , 8-inch diagonal sheathing, “ “ “ “ “	9.2	20,300	7.8
“ “ “ “ , studs and horizontal sheathing, green lumber then seasoned one month	6.0	12,700	4.9
8-inch horizontal green sheathing, two 8d nails, no braces, panel seasoned one month	0.5	1,700	0.7
†“ “ “ “ “ “ “ “ “ “ “ “ “ “ “	0.7	1,800	0.7
“ “ diagonal “ “ “ “ “ “ “ “ “ “ “ “	1.7	.....	...
†“ “ “ “ “ “ “ “ “ “ “ “ “ “ “	1.7	.....	.....
8-inch horizontal sheathing, two 8d nails, no braces, alternate sunshine and rain one month	0.7	2,175	0.8

TEST OF PANELS WITH WINDOW AND DOOR OPENINGS
(TABLE 2.)

Openings	Description of Panel Panel frames consisted of 2 by 4-inch upper and lower plates, vertical studs spaced 16 inches, and triple end posts	Stiffness factor	Maximum Load Pounds	Strength factor
window	8-inch horizontal sheathing, 1 by 4-inch let-in braces	3.0	6,500	2.5
“	“ “ diagonal “ , no braces, boards in tension	3.1	13,000	5.0
window and door	8-inch horizontal sheathing, no braces	0.7	2,100	0.8
“ “ “	“ “ diagonal “ , “ “ , boards in tension	1.4	10,240	4.0
“ “ “	“ “ “ “ “ “ “ “ “	1.4	10,150	3.9
“ “ “	“ “ “ “ “ “ “ “ compression	0.8	3,250	1.3
“ “ “	“ “ “ “ “ “ “ “ “	1.2	3,400	1.3
“ “ “	8-inch horizontal sheathing, 1 by 4-inch let-in braces	1.5	5,650	2.2
“ “ “	8-inch horizontal sheathing, no braces, 6-inch bevel siding	1.1	3,400	1.3
“ “ “	“ “ diagonal “ , boards in compression, 6-inch bevel siding	2.0	8,500	3.3
“ “ “	“ “ “ “ , “ “ tension, “ “ “ “	3.3	13,900	5.4
“ “ “	“ “ horizontal “ , 1 by 4-inch let-in braces, 6-inch bevel siding	2.7	8,880	3.4
“ “ “	Plaster on wood lath, no sheathing	2.3	4,200	1.6
“ “ “	“ “ “ “ , 8-inch horizontal sheathing, no braces	2.4	5,800	2.2
“ “ “	“ “ “ “ , “ “ diagonal “ “ “	2.8	11,300	4.4
“ “ “	“ “ “ “ , “ “ horizontal “ , 1 by 4-inch let-in braces	4.1	9,360	3.6

* All panels 9 by 14 ft., except those marked (†) which were 7 ft. 4 in. by 12 ft. 1⅝ in.
‡ Test stopped at 20,000-pound load.

Source: U. S. Forest Products Laboratory

Examples of Buildings *Effectively* Braced That Resisted Hurricane Pressures

A. N. Sample of Pampano, Florida. The owner of this home was familiar with hurricane conditions. His house was sheathed diagonally with lumber and each pair of rafters knee braced to the ceiling joists. The corners of the building are braced between studs and diagonal braces are let in over window and door openings. This building was built 16 years ago and suffered damage only to 4 windows, blown in during the storm.

A 2½-story frame home of West Palm Beach. The only damage was to a few windows and loss of a few composition shingles put on over the old wood shingles.

Home of L. H. Singleton of West Palm Beach. This building directly exposed to the storm, came through practically undamaged. Corner braces of 2x4's had been cut in between studs from roof plates to sole plates.

Examples of Buildings *Ineffectively* Braced To Resist High Wind Pressures

Flimsy frame construction characteristic of colored residential districts suffered severely under hurricane pressure. The buildings above were framed with 2x4 studs on 24" centers and no bracing. The buildings had single floors and were not tied down to the small concrete piers on which they rested. Destruction of buildings so constructed, by high winds, is almost inevitable.

An example of poor roof anchorage. Except for the tearing away of the porch roof, very little damage has occurred to this small dwelling.

In the Rockford tornado there were many instances of houses being dislodged from their foundations. Proper anchoring of the sill to the foundation in most cases would have prevented serious damage.

The Miami and other windstorms of a few years ago definitely proved that sound framing will successfully resist high wind pressures. Equally it proved that failure to build properly, irrespective of the materials used, is disastrous to the building owner. On page 12 are photographs of three frame residences directly in the path of the storm, which came out practically undamaged

That buildings must be framed properly to withstand high wind pressure is visually apparent by a glance at the photographs which show the damage caused in some recent heavy wind storms. The causes of the failures shown are almost apparent. In one case it is cheap construction, not adequately built and in the other two instances failure to anchor properly. Simple precautions would have prevented serious damage in each of the two latter cases and the damage shown in the destruction of the flimsy frame buildings merely substantiates the theory of sound construction.

Commenting on the test results, the Forest Products Laboratory's report states:

> "Plaster on wood lath may furnish all the rigidity necessary for most purposes under normal conditions However, as the plaster begins to crack from shrinkage, settlement, or other causes, the rigidity of the sheathing comes more and more into play, thus in violent winds or earthquakes it is the sheathing that becomes all important in preventing complete destruction. It is logical too that slightly more resistance than is necessary to resist ordinary distorting influences will in the long run more than pay for itself through diminishing, if not entirely eliminating, needless annoyances and frequent maintenance costs that result from the structure getting out of alignment. Diagonal or well-braced horizontal sheathing affords far more rigidity than horizontal sheathing without bracing. Either diagonal or horizontal sheathing is important from the standpoint of insulation and also assists in distributing concentrated loads. The amount of stiffness essential to good construction is not yet known and must be determined by experience.
>
> "The old 'braced-timber' frame which originated in New England had far more rigidity than was needed perhaps, but the hundreds of old houses still standing bear witness to the fact that rigidity went hand in hand with permanence. Today we cannot afford to use in moderate priced houses the heavy type of construction employed then. The modern adaptation of the braced frame with its small built-up corner posts and light corner bracing or the present-day balloon frame with the studs carrying through for two stories represent a great economy of material over the old style of braced frame.
>
> "Through a modern tendency to cut costs bracing is often omitted and horizontal sheathing is used because it is cheaper to put on. Although the inexpensive house is not necessarily an unsound house, nevertheless certain fundamental principles should be kept in mind so that when construction methods are employed to reduce costs the methods will be such that will result in no harm to the structure. Further, the added cost of adequate bracing is so small that it can hardly be felt in the total cost of the building."

NOTE—The above described experimental work was financed by the National Lumber Manufacturers Association on a cooperative basis with the Forest Products Laboratory, Madison, Wisconsin. The work was supervised and a full report prepared by George W. Trayer, Senior Engineer of the Laboratory staff. Copies of his report are available, upon request, either from the Laboratory or from the National Lumber Manufacturers Association, 702 Transportation Building, Washington, D. C. Fully illustrated directions for house framing details may be secured from the Association at 25 cents per copy.

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Grade-marked, trade-marked, National "TREE-MARK" lumber is now available in all commercial species.

The grade-marking of lumber is a commercial practice adopted by lumber manufacturers to safeguard the integrity of standard products, and to provide their buyers with assurance of lumber grade, manufacture, and size. The National "TREE-MARK," branded on lumber in conjunction with the manufacturers association marks indicating quality and/or species, is a financial guarantee to the first unloading buyer by the National Lumber Manufacturers Association that the lumber is of American Standard size and manufacture and that it conforms to such specifications as may be branded thereon by the licensed manufacturer.

Manufacturers grade, trade and species marks on lumber, hence, are the buyer's insurance of quality and species; and the National "TREE-MARK" the financial guarantee that the lumber is as marked. If your dealer does not have guaranteed grade-marked lumber, write us and give his name.

Manufacturers' certification of grade and tally are now available in all commercial species. "Shippers' Certificates of Car Contents" in the case of softwoods, and "Licensed Shipments" in the case of hardwoods, declare the exact contents of a shipment in terms of species, grades, items, working and footage as shipped by the manufacturer. Such certificates are, therefore, the buyer's insurance of quantity.

Buyers of lumber, irrespective of the amount, should insist upon grade- and trade-marked lumber. Carload buyers should insist on the added protection afforded by "Shippers' Certificates of Car Contents" or "Licensed Shipments," and thus be fully protected as to quantity as well as quality of each grade, species, and item.

NATIONAL LUMBER MANUFACTURERS ASSOCIATION

702 Transportation Building

Washington, D. C.

WHERE ADDITIONAL SPECIFIC LUMBER INFORMATION MAY BE OBTAINED

As the publications of the National Lumber Manufacturers Association deal with lumber in general, it is suggested that those desiring additional information regarding the respective species of woods listed below should make requests for definitions, grading rules, and publications concerning the special advantages and characteristics of each species to the following member associations affiliated with the National Lumber Manufacturers Association:

CALIFORNIA REDWOOD ASSOCIATION,
San Francisco, Calif.

Redwood

CALIFORNIA WHITE AND SUGAR PINE MANUFACTURERS ASSOCIATION,
San Francisco, Calif.

Sugar Pine, California White Pine, White Fir Douglas Fir, Incense Cedar

HARDWOOD MANUFACTURERS INSTITUTE,
Memphis, Tenn.

Ash, Basswood, Beech, Birch, Cherry, Cypress, Chestnut, Cottonwood, Elm, Gum, Hickory, Maple, Magnolia, Oak, Poplar, Sycamore, Tupelo, Willow, Walnut, Aromatic Red Cedar

NORTH CAROLINA PINE ASSOCIATION,
Norfolk, Va., and Macon, Ga.

North Carolina Pine

NORTHERN PINE MANUFACTURERS ASSOCIATION,
Minneapolis, Minn.

Northern White Pine, Norway Pine, Eastern Spruce, Tamarack

NORTHERN HEMLOCK AND HARDWOOD MANUFACTURERS ASSOCIATION,
Oshkosh, Wis.

Hemlock, Birch, Maple, Basswood, Elm, Ash, Beech, Tamarack, White Pine

SOUTHERN CYPRESS MANUFACTURERS ASSOCIATION,
Jacksonville, Fla.

Cypress, Tupelo

SOUTHERN PINE ASSOCIATION,
New Orleans, La.

Longleaf and Shortleaf Southern Pine

WEST COAST LUMBERMEN'S ASSOCIATION,
Seattle Wash., and Portland, Ore.

Douglas Fir, West Coast Hemlock, Sitka Spruce, Western Red Cedar, Port Orford Cedar

WESTERN PINE MANUFACTURERS ASSOCIATION,
Portland, Ore.

Pondosa Pine, Idaho White Pine, Larch, Douglas Fir, White Fir, Cedar and Spruce

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FIELD OFFICES

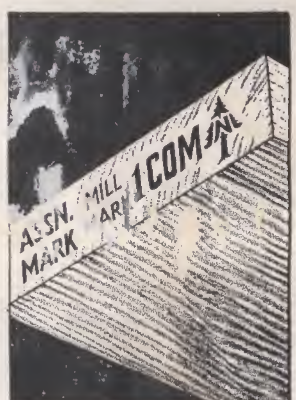
New York Chicago San Francisco
Boston Indianapolis Memphis
Minneapolis Los Angeles Portland
Pittsburgh Kansas City New Orleans

Use Tree Mark American Standard Lumber

Cooperating Organizations

British Columbia Loggers Association.
British Columbia Lumber & Shingle Manufacturers Association.
Maple Flooring Manufacturers Association.
National-American Wholesale Lumber Association.
National Association of Wooden Box Manufacturers.
Oak Flooring Manufacturers Association of The United States.
Red Cedar Shingle Bureau.
Service Bureau—American Wood Preservers Association.
Wood Office Furniture Associates, Inc.

Tree Mark Lumber is Guaranteed



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Service Bureau—American Wood Preservers Association.
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